WATER SUPPLY AND SANITATION ARE GOOD PREDICTORS OF DIARRHEA

Sumengen Sutomo * and Robert Tilden **

ABSTRAK

Pada tahun 1982 telah diadakan penelitian untuk mempelajari peranan penyediaan air minum dan sanitasi terhadap penyakit diare. Dua puluh satu variabel yang terdiri dari 9 variabel penyediaan air, 5 variabel sanitasi, dan 7 variabel sosial digunakan sebagai *independent variables*; dan diare sebagai *dependent variable*. Menggunakan analisa statistik *chi–square test* dan *logistic regression*, 4 variabel telah dipilih sebagai satu set prediktor penyakit diare. Di antara variabel-variabel itu kualitas air, cara penyimpanan air, dan cara pembuangan kotoran merupakan prediktor penyakit diare. Dengan kata lain penyediaan air dan sanitasi dapat dianggap sebagai prediktor yang baik untuk penyakit diare.

INTRODUCTION

Diarrhea is a major cause of morbidity and mortality in young children throughout the world, especially in developing countries. It is estimated that at least 4—5 million deaths per year are caused by acute diarrhea.[1,2] In Indonesia, diarrhea is the second cause of death in the population, and the principal cause of death of infants.[3,4]

Diarrhea is defined here as a condition characterised by abnormal frequency and liquidity of fecal discharge that weakens the body and leaves it with the fluid and salt needed to survive. It is considered diarrhea when there are more than three passages a day of watery, semi-solid, liquid of frothy excreta with or without blood or mucus and not necessarily accompanied by abnormal pain. It is acute and rapidly progressive with liquid or semiliquid stools varying from 3 to as many as 20 a day.[5,6,7]

The occurrence of diarrhea in the population can be influenced by many factors, such as agent, host and environment.[8] The agent of diseases can be bacteria, viruses and protozoa; host factors include social characteristics, such as age, education, ethinic group, religion, etc.; and environment is defined as the physical environment including water supply and sanitation. Each factor has many different variables that may relate to the occurrence of diarrhea in the population.

Since there is little information about which variables are considered as appropriate predictors of diarrhea, a study of these aspects was found to be pertinent, with the aim of identifying any such variables that may be considered as good predictors of diarrheal disease within the rural population.

MATERIALS AND METHODS

This study was carried out in the rural areas of Indonesia in October 1982. The nine provinces included in the study were: West Java, Central Java including Yogyakarta, East Java, Bali, North Sumatra, West Sumatera, Lampung, West Kalimantan, and South Sulawesi. The population comprised of people who live in the

* National Institute of Health Research and Development, Ministry of Health, Jakarta.

** School of Public Health, University of Michigan, Ann Arbor, USA

rural areas of these provinces. The household was selected as the smallest unit of sample, and the housewife was selected as the respondent. Selction of the household was conducted using a stratified random sampling procedure.

Data on water supply, sanitation, social characteristics, and diarrhea were collected from each househod. Water supply includes source of water, distance of source to the house, ownership of the source, quality of water at the source, its quality, collection method, storage of water at home, and its use. Sanitation includes type of excreta disposal facilities, distance of the facilities to the source, sanitary condition, and its use. Social characteristics include age, education, religion, ethnic group of the housewives, income, household size, and geographical stratification. These variables were classified into ordinal or nominal scales, and used as independent variables. Diarrhea was collected by interview of housewives using one week recall period, based on dichotomous classification, and used as a dependent variable.

Questionnaires were used as data collection instrument. Every respondent was interviewed, and observed to determine data on water supply and sanitation facilities for each household. Interviews and observations were conducted using combination of open and close ended questions. The questions were constructed according to the survey research guide developed by several authors.[9,10] The interviews were carried out by sanitarians under the supervision of health inspector from each province and the supervisor from Jakarta.

Data from the questionnaires were converted to useful information through data processing activities such as editing, coding, data entry, and final analysis. Several statistical methods and computer programs were employed for analysis. Since the dependent variable is classified on ordinal or nominal scales, the appropriate statistical methods of analysis were chi-square test and logistic regression.[11,12] The computer programs applied in the analysis were MIDAS (Michigan Interactive Data Analysis System), and BMDP (Biomedical Computer Program).[13,14] Finally, the information from the analysis was interpretated and reported.

RESULTS

There were 8597 households included in this study. Among these households, there were 369 households with cases of diarrhea and 8228 that did not have cases of diarrhea. Number of variables analyzed are 22 that include diarrhea as a dependent variable, and 21 independent variables.

The independent variables consist of 9 variables for water supply, 5 variables for sanitation, and 7 variables for social characteristics and geographical stratification. Table 1 shows list of all variables and their scales.

Table 1. List of dependent variables, independent variables and their Scales

Variable		Scale
Dependent variable	Diarrheal disease	Nominal (yes/no)
Independent variable		
Water supply	Source of water	nominal
	Distance	ordinal
	Ownership	nominal
	Quality	ordinal
	Condition	ordinal
	Quantity	ordinal
	Collection	nominal
	Storage	nominal
	Use	nominal
Sanitation	Disposal	nominal
	Distance	nominal
	Ownership	nominal
	Condition	ordinal
	Use	nominal
Social	Age	ordinal
	Education	ordinal
	Religion	nominal
	Ethnic group	nominal
	Income	ordinal
	Size	ordinal
	Strata	nominal

Since there are too many variables included in the analysis, it is imposible to run simultaneously the logistic regression using a computer program to select which variables are the best set of predictors for diarrhea. For this reason, chi-square test was employed as the preliminary selection of independent variables that may have an association with diarrhea.[15, 16] Table 2 shows the results of the test for association between water supply, sanitation, social characteristics and diarrhea at 5% level (p–value)

Tables 2. Test statistics for association between water supply, sanitation, social characteristics and diarrhea.

Variable	X^2	p-value	Association
WATER SUPPLY			
Source	22.92	. 01	+
Distance	2.11	.72	—
Ownership	7.56	.11	—
Condition	.92	.63	—
Quantity	3.35	.50	—
Quality	12.99	.00	+
Collection	18.86	.00	+
Storage	61.01	.00	+
Use of water	0.13	.72	—
SANITATION			
Disposal	21.52	.01	+
Distance	6.17	.10	--
Ownership	4.54	.21	—
Condition	2.25	.33	—
Use of latrine	31.44	.00	+
SOCIAL			
Age	32.27	.00	+
Education	21.76	.00	+
Religion	10.24	.02	+
Ethnic group	58.67	.00	+
Household size	22.64	.00	+
Income	3.05	.22	—
Strata	0.71	1.00	—

\+ Significant at 5% level.

At the first selection, there are eleven independent variables associated with diarrhea. These variables include 4 for water supply: source of water, quality, collection methods and storage; 2 for sanitation: type of disposal and use of latrine; 5 for social characteristics: age, education, religion, ethnic group, and household size.

In the next selection using logistic regression analysis, there are four variables selected as a set of predictors for diarrhea. These variables, its coefficient and p — value are shown in Table 3.

Table 3. Parameters of logistic regression for water supply, sanitation, and diarrhea.

Term	Coefficient	Standard Eror	Coef/SE	p-value
Quality	− 0.57	0.23	− 2.51	0.03
Age	0.25	0.09	2.81	0.00
Storage	0.38	0.17	2.26	0.03
Disposal	-- 0.94	0.44	− 2.16	0.01
Constant	5.40	1.40	3.85	—

These variables are quality of water at the source, age of housewife method of water storage at home, and type of excreta disposal facilities. The goodness of fit chi-square indicated that the multiple logistic regression equation fits the data very well. In addition, the improvement chi—square indicates that the p — value of each independent variable is very small. This means that the variables selected in the model are good predictors for diarrhea.

DISCUSSION

At the first selection, eleven of the independent variables indicated associatoons with diarrhea. Among these, the use of latrine was categorized also in the type of excreta disposal facilities. This information was already included in the type of disposal facilities with the classification; water seal latrines, borehole latrines, and overhung latrines. The use of latrine in the logistic regression model would duplicate the effect of the type of disposal, and therefore, this variable was not included in the logistic regression analysis. Thus, only ten independent variable are involved in further analysis.

Before the logistic regression analysis was performed, each variable was correlated each other to find out whether there is intercorrelation among these independent variables. When the independent variables are highly correlated, there are many different logistic regression functions providing good fits to the data. The estimated regression coefficient tends to vary widely from one sample to the next, and in such case Neter and Wasserman (1974) suggested that only imprecise information will describe the prediction. Since all coefficient from the correlation matrix are too small, there is no intercorrelation among the ten variables candidates. These variables meet the requirement for prediction values.[17, 18]

From the logistic regression analysis, four variables were selected as the best set of predictors of diarrheal disease. These are quality of water at the source, age of housewives, method of water storage at home, and type of excreta disposal facilities. The parameter for the model is shown in Table 2. The intercept $\beta 0$ is 5.40; while the coefficients for the remaining term are estimated as for $\beta 1$ = −0,57for $\beta 2$ = 0.25, for $\beta 3$ = 0.38, and $\beta 4$ = −0.94. The equation for the Ln (Odds) is estimated by: 5.40 − 0.57

(Quality) + 0.25 (Age) + 0.38 (Storage) – 0.94 (Disposal). In term of the logistic regression, the equation for the probability of not having diarrheal disease (P1) is :

Probability of not having diarrheal disease (P1) =

$$\frac{1}{1+\text{Exp}\,[-(5.4-0.57(Q)+0.25(A)+0.38(S)-0.94\,(D)]}$$

According to this model, the four variables selected as good predictors of the occurrence of diarrhea in the household are: quality of water at the source, age of housewives method of water sto-rage at home, and type of disposal facilities. Among these variables, two are variables of water supply, one is a variable of sanitation, and the other is a social characteristic.

The quality of water was limited to physical characteristics such as colour, smell, taste, and purity which did not represent a quality of water in term of chemical and bacteriological characteristics. Among 7984 households, 34.8 percent obtained good quality of water, 54.4 percent moderate quality of water, and 10,8 percent poor quality of water. The proportion of diarrhea for the households which had access to good or moderate quality of water is less than those who had access to poor water.[19,20]

The source of good or moderate quality of water is from improved source of water such as piping system, spring with protection, deep well pump, and shallow well pump. In contrast the source of poor quality of water is from unimproved facilities such as rivers, streams, ponds, and other insanitary sources. These sources of water have more exposed to bacteriological contamination than improved facilities. The households which had access to improved water supply would have less risk of having diarrhea than those who had access to unimproved facilities. Further study which emphasizes bacteriological quality of water should be carried out to provide better information on the relationship between quality of water and diarrhea.

Many types of containers were used by the households for water storage, such as contrainer made of soil, plastic, zinc, cement and others. Of 8501 households 19.1 percent had access to good containers, 71.5 percent bad containers and 9.4 percent had access to piping system in their houses. The proportion of diarrhea for households which had access to the piping system was significantly lesser than those who used containers.[20,21]

The type of excreta disposal is classified into adequate, less adequate and inadequate facilities.[18] Of 8482 households, 10.2 percent had access to adequate, 26.5 percent to less adequate and 63.3 percent to inadequate facilities. Inadequate disposal facilities would provide fecal contamination to soil, surface and ground water. There was a significant association between diarrhea and type of excreta disposal facilities. Households which had access to inadequate disposal facilities were more exposed to diarrhea than those with safe water and adequate disposal facilities.[19,20]

Since quality of water and method of storage were categorized in water supply, and type of disposal facilities was categorized in sanitation, it is clear that water supply and sanitation are good predictors of diarrhea. It is hoped that the result of the study would provide information that can be used to improve the strategies of water supply and sanitation program in relation to diarrheal disease in rural areas.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. A.A. Loedin MD, Head of the National Institute of Health Research and Development for giving him the opportunity to carry out this study, F.X. Setiady MD, DPH., Director of Health Ecology Research Center for his invaluable administrative support, and also would like to thank those who participated in this study.

The authors would like also to express his special thank to Dr. Michael A. Schork Department of Biostatistics, School of Public Health, University of Michigan for his assistance especially in selecting the appropriate method of statistical analysis, reviewing the data and interpretations; and to Morton S. Hilbert MPH, Dr. Robert N. Grosse and Dr. K.H. Mancy for their reviews, discussions, and critical comments of the data.

REFERENCES

1. Evans N Lloyed, H.A. Pickering, S.G.J. Goh and MGM Rowland (1984). Food and Water Hygiene and Diarrhea in Young Gambian Children. A Limited Case Control Study. Transaction of the Royal Society of Tropical Medicine and Hygiene 78, p. 209-221.
2. World Health Organization (1984). Programme for Control of Diarrhoeal Diseases. Manual for the Planning And Evaluation of National Diarrhoeal Diseases Control Programmes. WHO Geneva. 3 – 13.
3. Budiarso L. Ratna (1983). Sebab Kematian Bayi dan Anak Balita. Survey Kesehatan Rumah Tangga 1980. *Bull Health Stud Indon* 11(1) : 1 – 4.
4. Budiarso L. Ratna, J. Putrali, dan Muchtaruddin (1980). Laporan Survai Kesehatan Rumah Tangga 1980. Departemen Kesehatan R.I., Badan Penelitian dan Pengembangan Kesehatan, Puslit Ekologi Kesehatan - Jakarta: 45 – 50.
5. Rajasekaran P., P.R. Dutt K.A. Pisharoti (1976). Impact of Water Supply on the Incidence of Diarrhea and Shigellosis among Children in Rural Communities in Madurai. *Indian J. Med. Res.* 66, 2 August: 189 – 199.
6. Morley David (1975). Paediatric Priorities in the Developing World. Butterworth – Great Britain: 170–194.
7. Bureau for Science and Technology, Agency for International Development (1983). International Conference on Oral Rehydration Therapy. An Inventory of AID Supported Oral Rehydration Therapy and Diarrheal Disease Control Activities – Washington DC : 1 – 5.
8. Lilienfeld Abraham M. (1976). Foundation of Epidemiology Oxford University Press – New York : 32 – 34, 164 – 193.
9. Babbie (1973). Survey Research Methods. Wadsforth – Belmont, California. 187–203
10. Warwick Donald P., Charles A. Lininger (1975). The Sample Theory and Practice, Mc. Graw Hill – New York 265 – 327.
11. Afifi A.A. and Virginia Clark (1984). Computer Aided Multivariate Analisis. Life Time Learning Publications – Belmont California: 1 – 13, 287–307.
12. Andrews Frank M., Laura Klem, Terrence N. Davidson, Patric M. O'Malley, Williard L. Rodgers (1981). A Guide for Selecting Statistical Techniques for Analyzing Social Science Data. Institute for Social Research,

the University of Michigan — Ann Arbor : 15 — 16.

13. Dixon W.J., M.B. Brown, L. Engelman, J.W. Frane, M.A. Hill, R.I. Jennrich, and J.D. Toporek (1983). BMDP Statistical Software. University of California Press — Berkley, Los Angeles : 330 — 344.
14. Fox Daniel J., Kenneth E. Guire (1976). Documentation for Midas. Statistical Research Laboratory. The University of Michigan — Ann Arbor: 120 — 179.
15. Ott Lyman (1984). An Introduction to Statistical Methods and Data Analysis. Duxbury Press — Boston : 258 — 500.
16. Everitt B.S. (1979). The Analysis of Contingency Tables. John Willey & Sons. — New York: 38 — 66.
17. Neter John and William Wasserman (1974). Applied Linear Statistical Models, Regression, Analysis of Variance, and Experimental Designs. Richard D. Irwin – Illinois : 339 — 393.
18. Kerlinger Fred N., Elazar J. Pedhazur (1973). Multiple Regression in Behavioral Research. Rinehart and Winston — USA : 280.
19. World Health Organization (1976). Community Water Supply and Waste Water Disposal (Mid. Decade Progress Report. Report by the Directorate General. *Twenty Ninth WHO Assembly* May 6, 1976. p. 1, Annex 1, A 29/12 Rev 1 p. 1 — 10.
20. Sutomo Sumengen (1986). Water Supply, Sanitation, and Diarrheal Disease in Rural Areas of Indonesia. Doctoral Dissertation, School of Public Health University of Michigan — Ann Arbor : 1 — 144.
21. Sutomo Sumengen (1986). Water Supply, Sanitation, and Diarrheal Disease in Rural Indonesia. *Bull Health Stud Indon* 14 (4) : 1 — 9.